EXECUTIVE SUMMARY

A. INTRODUCTION

The Great Pond Diagnostic/Feasibility study began in November 4, 1994, as a result of Clean Lakes Program grant.

The lake's watershed is located in the Town of Kingston in the southeastern portion of the State of New Hampshire. It is located within a short distance from the state's three largest cities, Manchester, Nashua, Concord and within the driving range of the Lowell Metropolitan area.

The goals of the diagnostic study were to quantify the phosphorus inputs to Great Pond and to identify the sources of significant phosphorus loading.

The goals of the feasibility section were to evaluate potential watershed Best Management Practices that would reduce the supply of phosphorus to the lake and to identify possible lake restoration techniques that may be used if the lake quality deteriorated further. The feasibility section also discusses the most feasible, cost effective methods for implementing watershed management and lake restoration.

B. STUDY APPROACH

Prior to making recommendations for protective and restorative measures, a fuller understanding of such processes as lake flushing rates, groundwater influences, watershed utilization, sediment characteristics and nutrient sources had to be achieved. To this end, biologists began an intensive study to document the physical, chemical and biological processes of Great Pond. The glossary may be referred to for aid in understanding the technical terms.

1. Physical, Chemical, and Biological Monitoring

Measurements of water chemistry, plankton populations, chlorophyll-a and transparency were recorded. An inventory of macrophytic growth was documented. Detailed maps and an evaluation of the lake's littoral areas were completed. Sediment cores were extracted and analyzed for specific metals and phosphorus. Land use, topographical ground cover, and soils maps for the watershed were prepared.

2. Hydrologic Budget

The hydrologic budget for the gaging period (November 1994 through October 1995) quantified all significant sources of flow into Great Pond by gaging the inlet and outlet, estimating direct surface runoff, measuring precipitation and evaporation, and determining groundwater seepage rates with seepage meters and wells. Watershed tributaries were the greatest inflowing component to Great Pond, contributing 84 percent of the hydrologic budget. The Kelly inlet contributed 77 percent of the tributary share of water in the budget. The second greatest water contributor was groundwater, representing 7.6 percent of the hydrologic budget. Direct precipitation and direct runoff represented 8.3 percent of the total water budget of Great Pond.

Direct outflow or discharge from the outlet represented 86.6 percent of the outflow budget for the sample year. Evaporation accounted for 2.7 percent of the outflow. Water recharge into the groundwater was estimated to be 2.7 percent of the total discharge from the lake.

3. Nutrient Budget

Phosphorus loading, the primary factor limiting plankton and macrophyte growth, was determined by sampling phosphorus concentrations and multiplying by hydrologic volumes as quantified or estimated in the hydrologic budget. Phosphorus loading to Great Pond from nearshore septic systems was determined by direct measurement of groundwater phosphorus. Water column and sediment phosphorus concentrations were calculated, and a nutrient budget was prepared for the study year.

One of the most important goals of this study was to quantify the various avenues of phosphorus inputs to Great Pond. Chapter VIII discusses the annual phosphorus budgets for the lake.

The greatest single contributor of phosphorus to Great Pond was septic leachate/groundwater which contributed 41.4 percent of the external phosphorus load. The greatest combined source of phosphorus to Great Pond was contributed by subwatershed tributaries which produced 46.4 percent of the phosphorus loading. Kelley Brook accounted for 68 percent of the tributary phosphorus load. Other monitored sources included the direct runoff (6.6%) and atmospheric (5.6%).

4. Lake Modeling

The determination of the trophic state of a lake involves a comparison of the actual total phosphorus loading to the lake with the maximum loadings that the lake can tolerate before excessive algal and macrophyte growth occurs and transparency diminishes. A trophic state model is a mathematical relationship which, by incorporating such factors as phosphorus loading and hydraulic retention time, allows a lake to be classified as oligotrophic, mesotrophic, or eutrophic. Four different classification methods were utilized, and their results are compared for this study. The trophic models classify Great Pond in the mesotrohpic/eutrophic state.

C. STUDY RESULTS

Great Pond is a typical dimictic lake exhibiting weak thermal stratification into three layers during the summer months and mixing completely during the spring and fall overturns each year. During the summer months, the bottom layer (hypolimnion), from 5.0 m to the bottom depth of 13.5 m, frequently exhibited anoxic or very low dissolved oxygen conditions. Total phosphorus concentrations were elevated in the hypolimnion, indicating internal phosphorus loading.

In-lake phosphorus concentrations at Great Pond ranged from a mean study year minimum of 8.0 µg/L in the upper layer during the spring to a maximum mean of 84.0 µg/L in the lower layer. Maximum in-lake total phosphorus concentrations were measured in the lower layer. Maximum total phosphorus concentrations were 615 µg/L recorded at Ball Road inlet. The minimum total phosphorus concentrations was 7 µg/L at Kelley Brook.

The diatom *Asterionella* was the dominant phytoplankton during the fall, winter, and spring months. During early to mid summer *Dinobryon* and *Synura* became dominant, and the bluegreen *(cyanobacteria) Anabaena* was observed to appear in substantial numbers. By late summer the cyanobacteria Oscillatoria and Microcystis became the dominant species.

In general, the zooplankton was dominated by the rotifers *Polyarthra* and *Keratella* and by the crustaceans *Daphnia, Bosmina* and Calanoid copepods.

Chlorophyll a values were less than 4mg/m^3 for fall and spring and ranged from 4 to 6 mg/m^3 during the summer. Transparency values ranged from 3 to 4 meters throughout the year.

Macrophyte growth in Great Pond was typical of a mesotrophic New Hampshire lake. The plants observed are all plants found in New Hampshire waters. No exotic or non-native plants were documented. The non-rooted plant bladderwort was the most abundant plant, with water lilies also being listed as relatively common.

D. PROJECT RECOMMENDATIONS

The Town of Kingston, the Kingston Conservation Commission and the Great Pond Association (GPA) have invested considerable amounts of time and effort to ensure the safekeeping of water resources within Kingston. The Wetlands Conservation Area, Aquifer Protection District and the participation of the GPA in the New Hampshire Volunteer Lake Assessment Program ensures that the water resources in Kingston will have protection in the future. In order to create a more intensive and comprehensive protection and preservation strategy for water resources in Kingston, specifically within the Great Pond watershed, the coordinators of the Diagnostic/Feasibility Study recommend the following watershed management strategies.

1. Zoning Recommendations

The Town of Kingston should adopt a watershed protection overlay district for the Great Pond Watershed. This effort should be coordinated with the Town of Danville where much of the upper watershed lies.

In 1995 the Office of State Planning reviewed Kingston's ordinances and made several valuable recommendations; if the Town of Kingston has not adopted those recommendations they should do so.

2. Education

The Town of Kingston and the Great Pond Association should initiate an education program and intensify existing educational efforts aimed at lake residents, transient lake recreationist, and private/public beach users.

The use of the local media to provide tips on lake protection can be a valuable source of information. Signs posted at public beaches and launches help educate the transient users on lake friendly practices while utilizing the waterbody.

3. Volunteer Monitoring

The Great Pond Association (GPA) should continue to participate in the New Hampshire Volunteer Lake Assessment Program on an annual basis. The continued compilation of data to assess long term water quality trends is an essential tool in the construction of lake and watershed protection plans for Great Pond. The current scope of the volunteer monitoring program at Great Pond will be adjusted to focus upon the anticipated water quality improvements resulting from the recommended watershed management techniques and possible lake reclamation project.

The Department of Environmental Services Biology Bureau will work with the GPA monitors to develop an expanded monitoring program if funding is procured for the lake reclamation recommendations.

4. Best Management Practices for Agriculture

An educational program or the distribution of Agricultural BMP Manuals will be made available for those people in the watershed who practice animal husbandry or manage “hobby farms”.

Hobby farms, with one or more animals, may have poor grazing practices, too many animals per acre, unrestricted access to streams, poor waste management practices and poorly drained soils. Such farms have limited space and capital with which to construct facilities for animal management. They have not traditionally been eligible for cost-sharing grants from federal or state programs.

Since small farms contribute to nonpoint sources of phosphorus and may even contribute more phosphorus than larger farms that practice BMPs, an educational program is needed on small farm BMPs for waste and pasture management.

5. Best Management Practices for Silviculture

Silviculture activities in the Great Pond watershed must be strictly enforced and regulated. Frequent inspections of silviculture activities may detect a potential water quality problem before it is too late for remedial action.

The Great Pond watershed land-use includes 76% forested, wetlands and open water. As such, there is potential for water quality impacts due to silvicultural activities. Performance standards and plan review for silvicultural activities are regulated by the State through timber harvesting and water quality protection laws. Regulation prohibits the placement of slash and mill waste in or near waterways, and limits clear-cutting near great ponds and streams. These requirements may mitigate to some degree water quality impacts associated with timber harvesting. More stringent local regulations could increase the setback requirements for disposal of slash.

6. Watershed Management

Watershed management projects have been preliminarily designed with specific goals to decrease stormwater flows, to treat the discharge and to reduce the amount of pollutants that reach the pond. Each designed Best Management Practice included partial engineering designs, a list of project materials and the approximate costs to complete the project. Watershed management projects were proposed for the following sites:

- bank stabilization at the Adirondack Shelter, Kingston State Park;
- erosion control BMPs at the Lincoln Brook Road station;
- erosion control BMPs at the Ball Brook Road station;
- erosion control BMPs at Kingston State Park; and
- sawdust waste management at the Cheney Mill.

7. Wastewater Treatment

a. Sewering

Based on the diagnostic portion of this study, sewering all or sections of Great Pond might eliminate up to 20 to 30 percent of the entire phosphorus load to the lake. In 1990, Beaver Lake in Derry, New Hampshire was sewered at a substantial cost to the lake property owner. Since Beaver Lake was sewered, it appears the phosphorus has decreased in the lake and transparency has increased. However, it is probable that the nonpoint watershed management programs recently implemented at Beaver Lake also contributed to improved lake quality. At this point, the nearest wastewater treatment facility to Great Pond is in the Town of Exeter. The engineering costs and the cost of laying sewer pipe to the nearest interceptor makes sewering cost prohibitive for the Great Pond community.

b. Alternative Systems

As the Great Pond study shows, many of the present septic systems discharge minimally treated wastewater into the groundwater and into the surface water due to hydraulic failure and/or inadequate soil conditions. This discharge is a source of phosphorus to the pond which has impaired water quality.

There is a clear need, throughout ecologically sensitive areas in New Hampshire, for the application of alternative wastewater treatment technologies. These technologies must be effective, yet moderately priced and simple to maintain for individual residences, clusters of residences, resorts and other business that depend upon on-site systems for wastewater treatment. Although a complete cost analysis for all alternative systems is beyond the scope of this report, both the cluster system engineered by G& Underwood Engineers, Inc. for Flints Pond and other newer developed state of the art systems should be further researched and implemented within the Great Pond immediate watershed.

c. Subsurface Systems

In the event that sewering Great Pond is cost prohibitive to the town and lake residents, an annual septic tank pumping program for Great Pond should be initiated through the lake association and Town Health Officer. Many concerned lake residents would volunteer for this worthwhile program. Records of those participating in the program and the dates of pumping should be updated each year.

8. Phosphorus Inactivation

Phosphorus precipitation and sediment inactivation are lake restoration techniques that reduce phosphorus concentration and thereby limit the growth of phytoplankton. Sediment phosphorus inactivation results in longer term lake quality improvement when compared to water column precipitation. Sediment inactivation is particularly useful in accelerating lake improvement in those areas where internal phosphorus release represents a significant contribution to the phosphorus budget and all watershed phosphorus contributions have been reduced.

Great Pond has two basins in which anoxia occurs and internal phosphorus release to the hypolimnion will result. The north basin contains 11.1 ha within the 20 foot depth contour while the south basin contains 14.8 ha of 20 foot contour depth. Approximately 26 ha or 32 percent of the area of Great Pond is conducive to three layer stratification. The estimated cost for sediment phosphorus inactivation of 26 ha for Great Pond will range from approximately $17,000 using the new barge system, to $36,600 (1990 dollars) using the modified harvester, similar to that used at Kezar Lake, New Hampshire. Figures are dependent upon the application methodology and include equipment, labor and chemical cost.